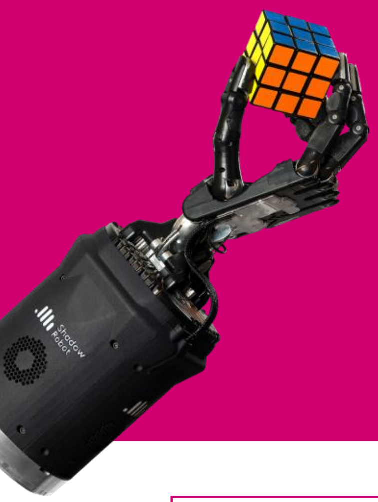

How, where and why are researchers using the Shadow Dexterous Hand?

TELEOPERATION AND HUMAN-ROBOT INTERACTION (HRI)

Since the Shadow Dexterous Hand offers a similar degree of freedom to the human hand, the Shadow Dexterous Hand is a target platform to perform teleoperation and human-like motions.

In fact, under-actuated hands or hands with lower degrees of freedom quickly limit the range of movements that can be executed by the user. This comes from the fact that on top of learning/designing a mapping between the movement of the human, another mapping must be learned to check whether the human hand configuration is reachable by the hardware.

For instance, in their paper published in 2019, Li et al. propose an end-to-end Deep Learning approach to control the Hand through a simple camera. The motion of the hand captured by the camera would then be reproduced by the actual robot Hand. Similarly, the Shadow Hand is often used in works involving complex HRI, such as object handover.

As pointed out by Christen et al., in order to make HRI as natural as possible, the robot should be able to display human-like behaviour. In their work, the authors record motion capture data and use them to generate complex policies (with Reinforcement Learning) for a robot arm and the Shadow Hand to have complex interactions (hand clap, shaking hand, finger touch, etc.). The fact that data captured from humans can be easily transferred to the Hand is a big advantage for such works.

In 2020, Ruppel and Zhang proposed a novel learning and control framework that combines artificial neural networks with online trajectory optimisation to learn dexterous manipulation skills from human demonstration. They are able to transfer the learned behaviours to real robots. Here, the humans control the robot through an instrumented glove, motion capture and tactile data. The end result of such a pipeline even considers kinematics, safety and feasibility constraints, which make the Hand safe to work in environments with humans.

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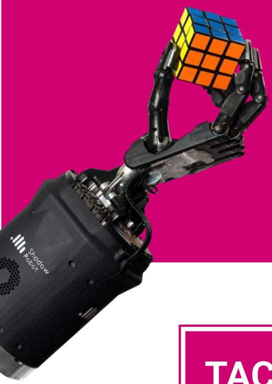


TACTILE EXPLORATION AND REACTIVE BEHAVIOURS

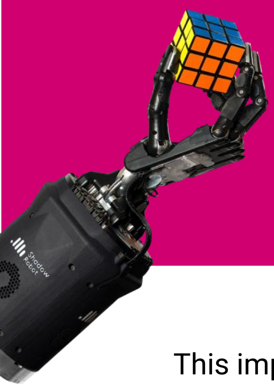
An increasing number of works have deployed sensors on the Shadow Hand for a wide range of tasks. Due to the high number of degrees of freedom, grasps generated by the Hand can better fit a wide range of objects, compared to parallel jaw grippers or under-actuated hands. In addition, it also means that more space can be covered with smaller movements from the robot arm. For this reason, cutting edge tactile sensors, such as the BioTac have been mounted on the Hand to create force and tactile-based reactive control for stabilising objects during the grasping stage.

For instance, Deng et al. propose a full pipeline based on vision, force and tactile sensing to robustly grasp objects. The Hand is reported to be a good platform as it allows to quickly and efficiently explore objects with tactile sensing based on a first estimation built from vision. Similarly, Ganguly et al. propose a new closed-loop and compliant control algorithm that includes BioTac sensors to drastically improve the grasping stability of the Hand, even if the pre-grasp was not accurate.

Moaed et al. recently proposed similar approaches but relying on a neural network that classifies the direction of slip, based on the tactile input of all the fingertips, in real-time. Based on the direction inferred by the neural network, the motion of the fingers are generated to make the slip stop, thus having reactive behaviours, that can be compared to reflexes.

DEXTEROUS MANIPULATION

Due to its impressive number of degrees of freedom, the Shadow Dexterous Hand is commonly used by Machine and Deep Learning researchers to learn complex in-hand manipulation motions. For instance, Andrychowicz et al. managed to learn robust policies to turn a cube inside the Hand so that a designated face points towards a given direction.



This impressive feat has been possible by combining powerful Reinforcement Learning algorithms along with simulation, a wide range of tactile sensors as well as very robust hardware, dexterous enough to roll a cube inside a single Hand by moving the fingers. Similarly, Li et al. applied a similar approach to solving a randomly shuffled 3x3 Rubik's cube with the Shadow Hand.

Naganbandi et al. also recently proposed a different approach for learning complex in-hand manipulation movements with fewer data. For instance, with only 4 hours of real-world data, they managed to train and deploy complex motions such as valve rotation, in-hand reorientation, handwriting, and manipulating Baoding balls with the Shadow Dexterous Hand.

Although most of the autonomous grasping algorithms have been designed and deployed for parallel jaw grippers and/or suction cups, it has been proved that such devices can not cope with a wide variety of objects. For this reason, an increasing number of works are focusing on developing grasping algorithms for multi-fingered hands.

AUTONOMOUS GRASPING

Once again, the Shadow Hand is a target choice among researchers. Liu et al., Yu et al. and research by Shang et al. all propose to learn Grasp Pose generation for high degrees of freedom.

Since most of the existing grasping datasets have been generated and labelled for parallel jaw grippers, all come up with a new solution to reuse such valuable datasets and transform the grasping representation to fit the Shadow Hand.

Want the Shadow Dexterous Hand for your research?

Email us at contact@shadowrobot.com and ask about our academic packages!

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